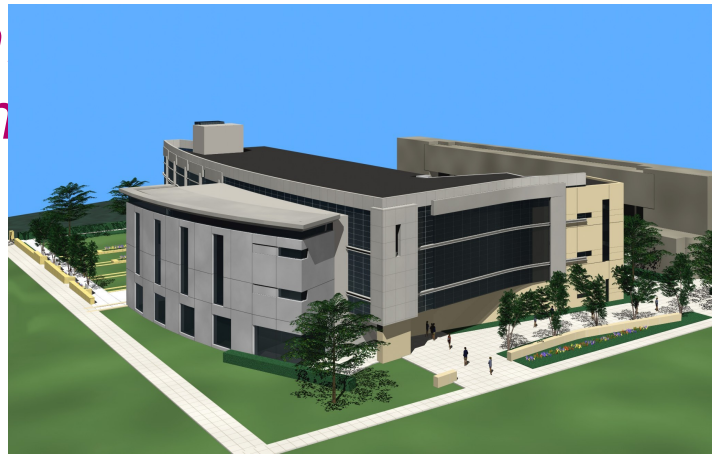
A University-Based Program Developing Design Engineers for Instrumentation and Control Systems

Patrick L. Walter
Department of Engineering
TCU
Fort Worth, TX

Introducing Design in the TCU Engineering Curriculum

The TCU Engineering program provides a significant design emphasis. The core of this program is three (3) interdisciplinary courses:



ENGR 30903: Issues in Engineering Design

typically 2nd semester Jr. Year

ENGR 40903: Systems Design I

typically 1st semester Sr. Year

Junior Course Topics

- *Engineering ethics, product liability*
- *Specifications/needs analysis*
- *Feasibility studies*
- *Reliability and testing*
- *Patents*
- *Project management*
- *Fault tree analysis*
- *Testing*
- *Hazard analysis and SOPs*
- *Human factors/ergonomics*
- *Economic analysis & budgeting*
- *etc.*

Senior Program Student Role

- *Clarify specifications*
- *Elect program manager/support managers/coordinate teams/divide work*
- *Assign technical and administrative job functions to each participant*
- *Originate formal design/budget reviews*
- *Perform customer coordination*
- *Formalize design drawings/provide shop interface*

Senior Program Student Role

- *Formulate and adhere to PERT charts*
- *Perform all component selection and initiate procurement*
- *Assemble deliverable and test for specification compliance*
- *Prepare final design report*
- *Prepare final design presentation*
- *Perform project delivery and setup*
- *Perform peer evaluation*

PROJECT HIGHLIGHTS

Projects to Date

- ***1995**: Designed and qualified telemetry compatible pressure and acceleration measuring systems for space flight*
  - *Customer: Privatized Launch Systems (TCU, Fort Worth, TX)*
  - *Funds: $1,300*

Acceleration Measuring System

Accelerometer Parts and Assembly Tooling

compression design using piezoelectric ceramic PZT5

Acceleration Measuring System

Accelerometer Thermal Sensitivity Testing

frequency response and thermal sensitivity testing on

Acceleration Measuring System

Accelerometer Base Strain Test (per ISA specificat

Instrument Society of America SP37.14 test specification -

Acceleration Measuring System

Charge Amplifier Circuit Breadboard Testing

testing prior to circuit layout

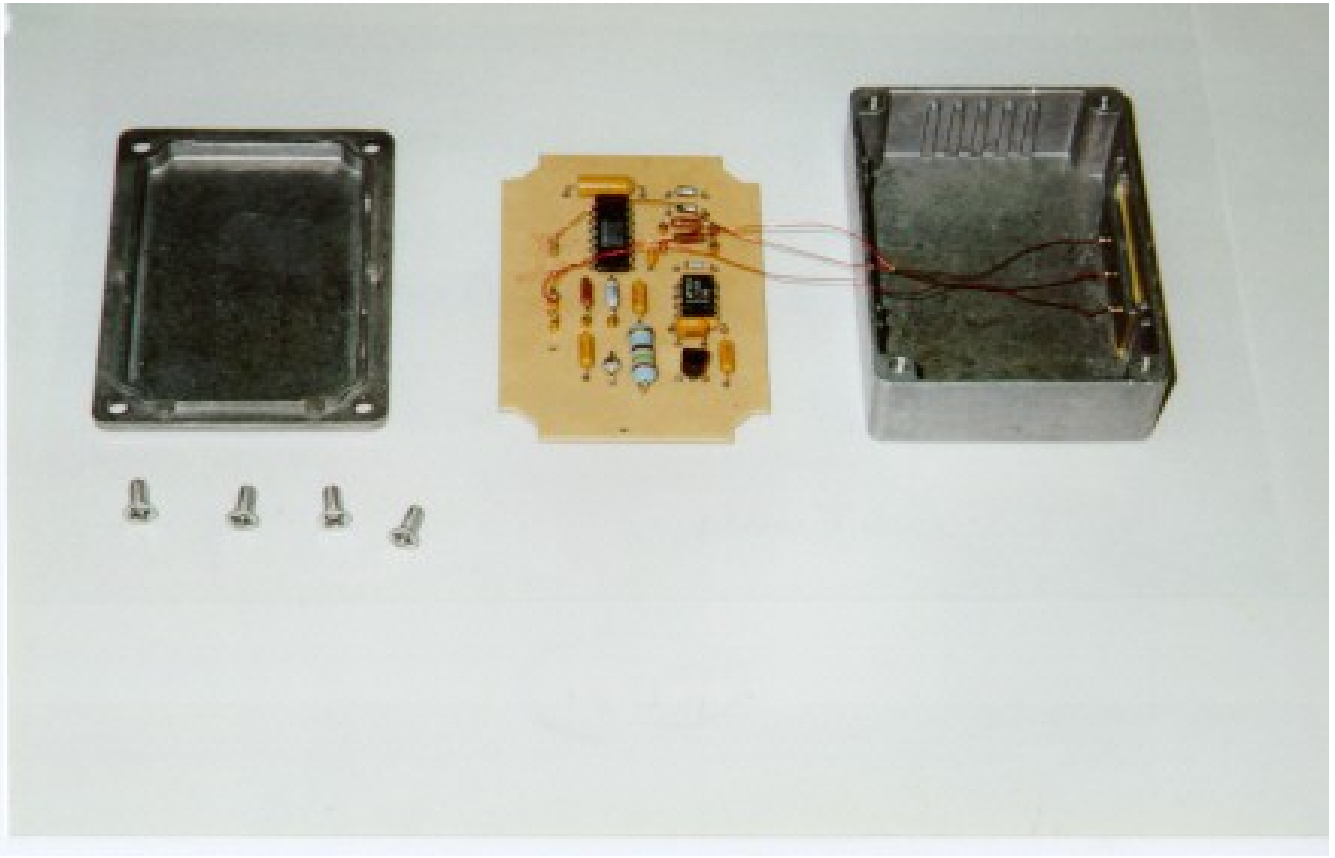
Acceleration Measuring System

Charge Amplifier PC Board Fabrication

circuit board design and fabrication

Acceleration Measuring System

Charge Amplifier Board With Chassis Box



operates from 28 +/- 4 VDC with telemetry compatible
0 - 5 VDC output limited and center biased

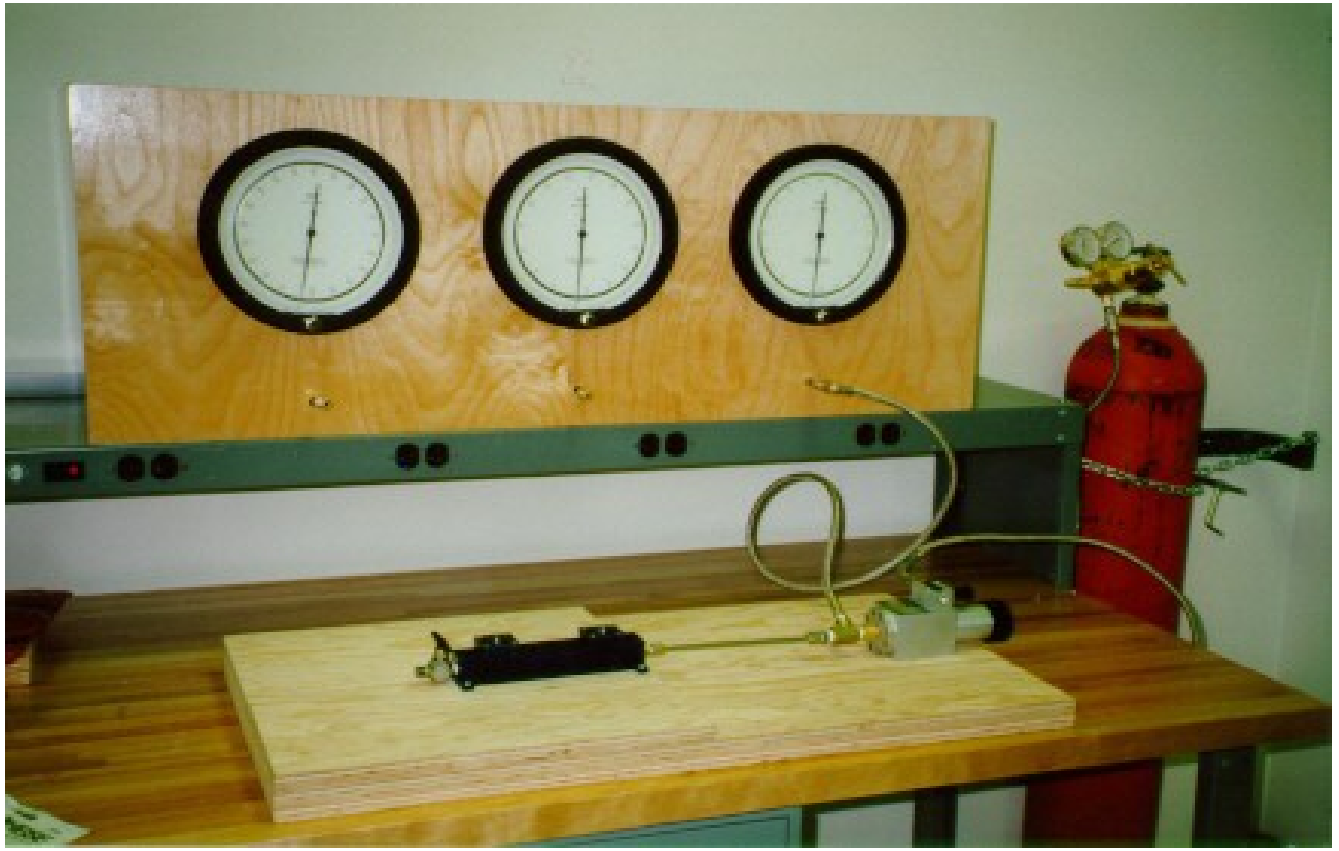
Acceleration Measuring System

Charge Amplifier Being Qualified to Random Vibra

random vibration representative of rocket test environment

Pressure Measuring System

Pressure Bench and Manifold Built for Functional T



0 - 1,000 psig test system: manifold, volumetrics controller, gages

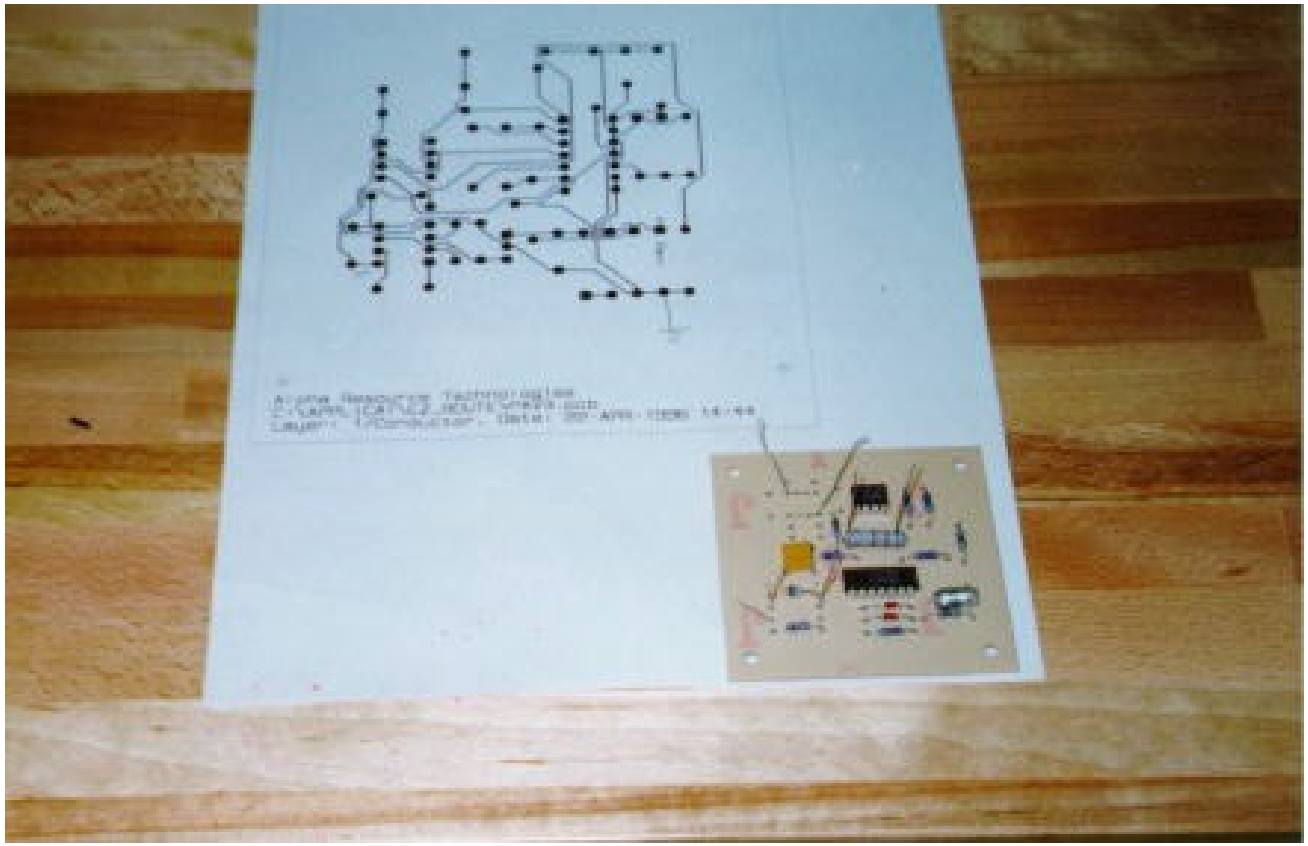
Pressure Measuring System

Circuit Board Layout

software designed board layout

Pressure Measuring System

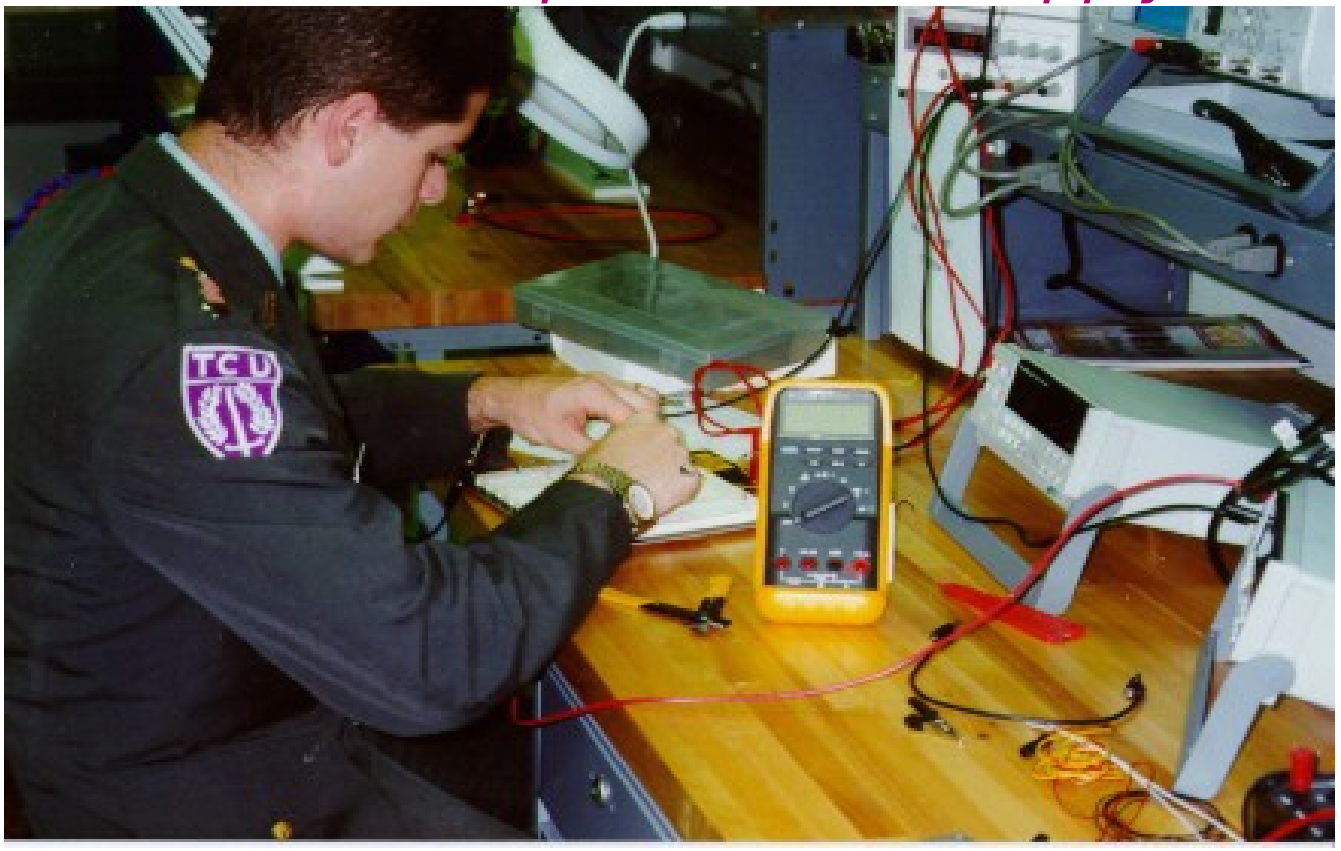
Final Board In Progress



partial board assemble in final configuration

Pressure Measuring System

DC Differential Amplifier/Power Supply In Process



circuit breadboard: 0-10 VDC power, 0-5 VDC out, diode limiting, ...

Pressure Measuring System

Pressure Transducer Under Test

linearity check of strain gaged diaphragm only

Observations 1995-1996 Project

- *53/56 aerospace specifications in the first Capstone project were satisfied.*
- *Students gained valuable experience in project management and teaming.*
- *Problems encountered were both technical and personality based.*
- *Industrial presentations contributed to the student design experience.*
- *With guidance, students appeared capable of handling major industrial projects.*

Projects to Date

- ***1996**: Cold gas shock tube for testing dynamic pressure instrumentation for gas turbines*
  - *Customer: Endevco, San Juan Capistrano, CA*
  - *Funds: $14,200*

Key Specifications (1/2)

- *Design Goal: Design a shock tube system to generate pressure pulses with short risetimes and large amplitudes for pressure transducer calibration and transfer function determination.*
- *Specifically:*
  - *support development and production testing of piezoelectric transducers*
  - *data acquisition system to accompany*

Key Specifications (2/2)

- *safe, robust, easy to operate*
  - *by production personnel*

- *Detailed Specifications (categories)*
  - *PERFORMANCE*
  - *GAS MEDIUM*
  - *PRESSURE GAGES*
  - *TIME OF ARRIVAL TRANSDUCERS*
  - *MECHANICAL*
  - *DATA ACQUISITION*

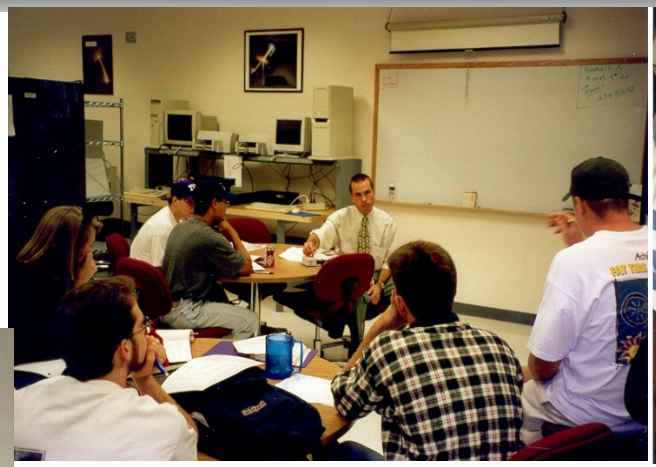
  28 TOTAL

1996-1997: Cold Gas Shock Tube

Projects to Date

- ***1997**: Automated system for the calibration of linear displacement measurement systems (LDMS)*
  - *Customer: Bell Helicopter Textron, Fort Worth, TX*
  - *Funds: $9,200*

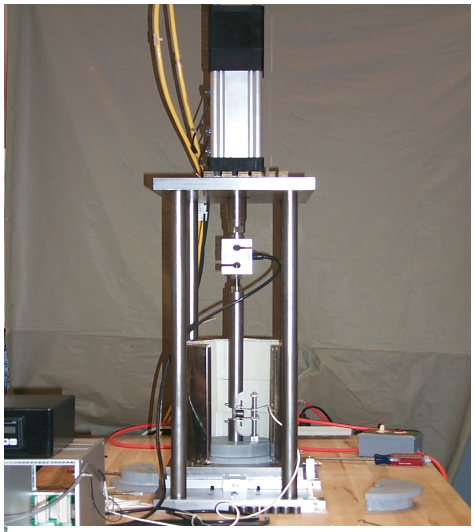
System for the Calibration of Linear Measuring Systems



Projects to Date

- ***1998:*** *Fracture Toughness Tester*
  - *Customer: RockBit International, Inc.*
  - *Funding: $18,000*

Toughness Tester for Tungsten Carbide Bit Inserts



Procedure for Testing ASTM Based

- Minimum of 3 tests needed with closeness of measu value
- 3 loading and unloading cycles per test
- Record for each test should include:
  - Specimen type
  - Environment of test
  - Diameter, B
  - Length, W
  - Height, H
  - Chord angle, θ
  - Slot thickness, t
  - Crack overhang, Δb
  - fracture surface conditions
- Compute and list the K_{ICSR} factor

Dimension Correction Factor

Correction factors:

- for a_o

$$C_a = 1 + \frac{1.8(a_o - a_{onom})}{B}$$

- for W

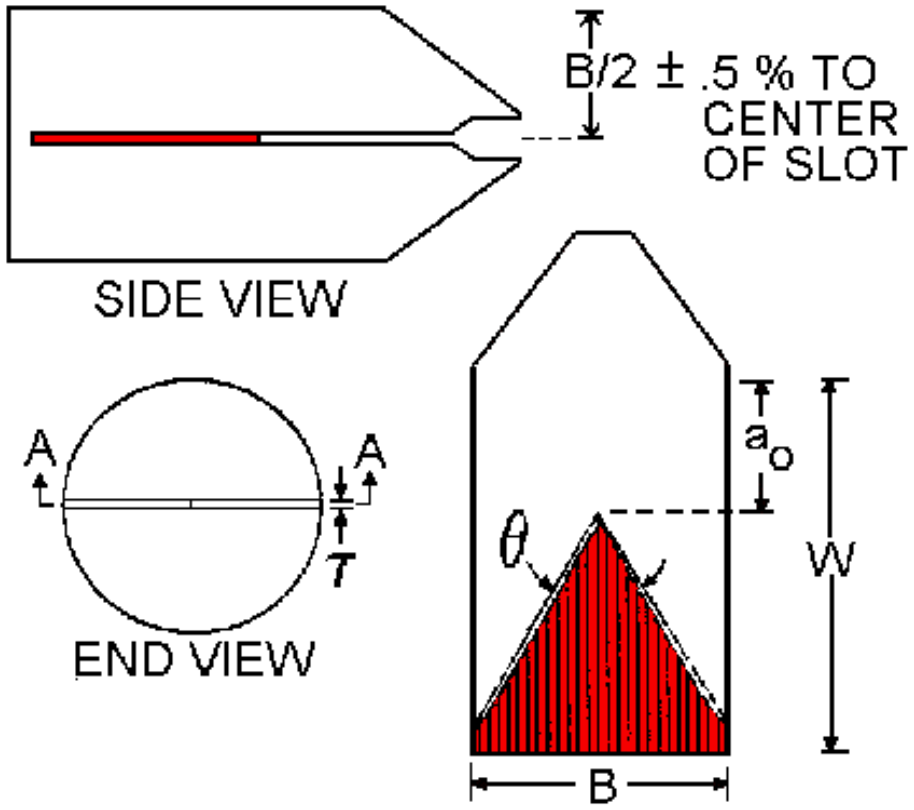
$$C_W = 1 + \frac{.7(W - W_{nom})}{B}$$

- for θ

$$C_\theta = 1 - .015(\theta - \theta_{nom})$$

- for τ

$$C_\tau = 1 - \frac{1.25(\tau - \tau_{nom})}{B}$$



Calculation of K_{ICSR}

- Fracture Toughness, K_{ICSR}

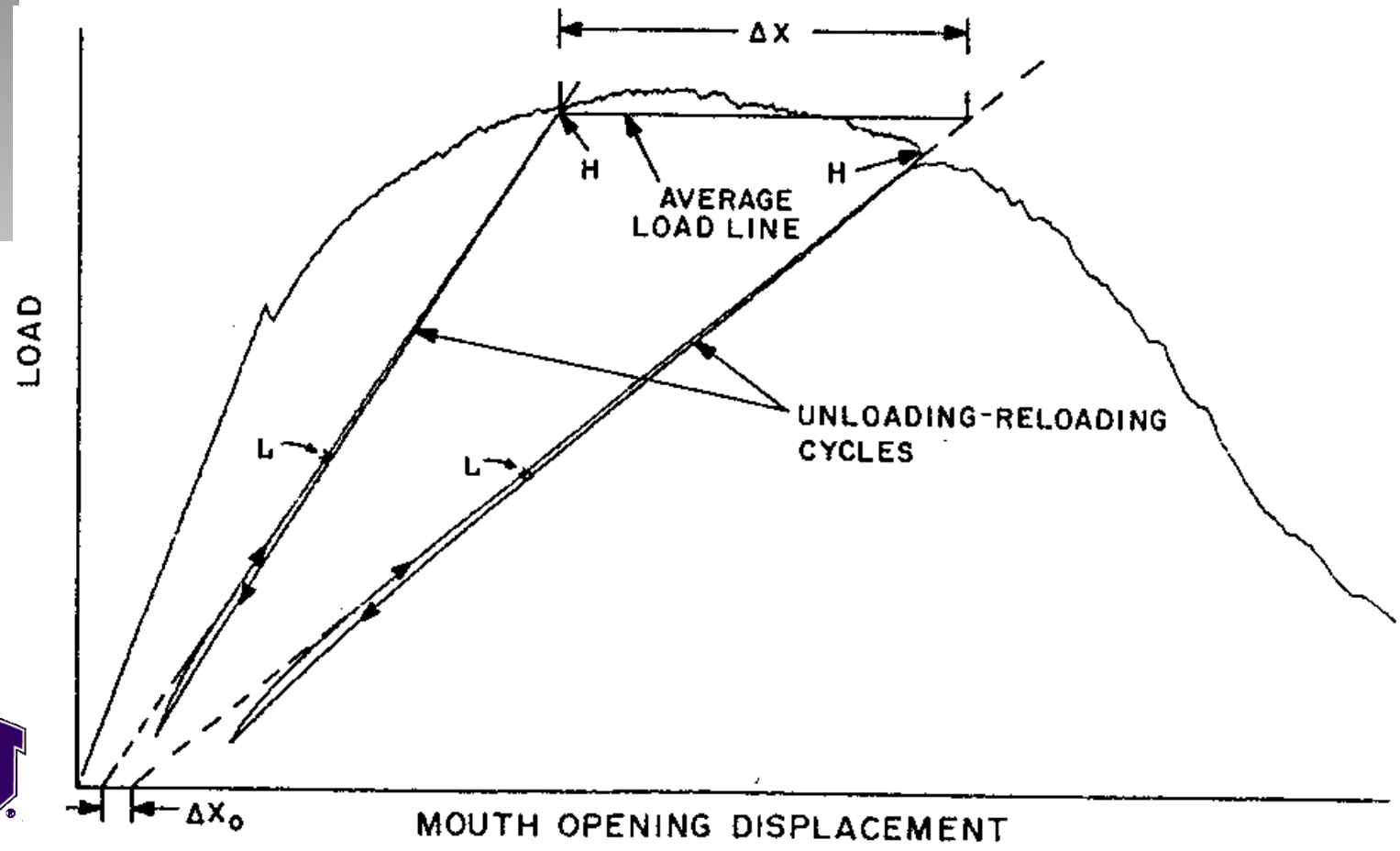
$$K_{QSR} = \frac{AF_C C_C (1+p)}{B}$$

- Where:
  - F_C = maximum load on the experiment
  - $C_C = C_a C_W C_\theta C_\tau$ = dimensional correction factor
  - $A \cong 22$ = constant determined by specimen geometery

$$p = \frac{\Delta X_o}{\Delta X}$$

ΔX_o & ΔX - found on graph

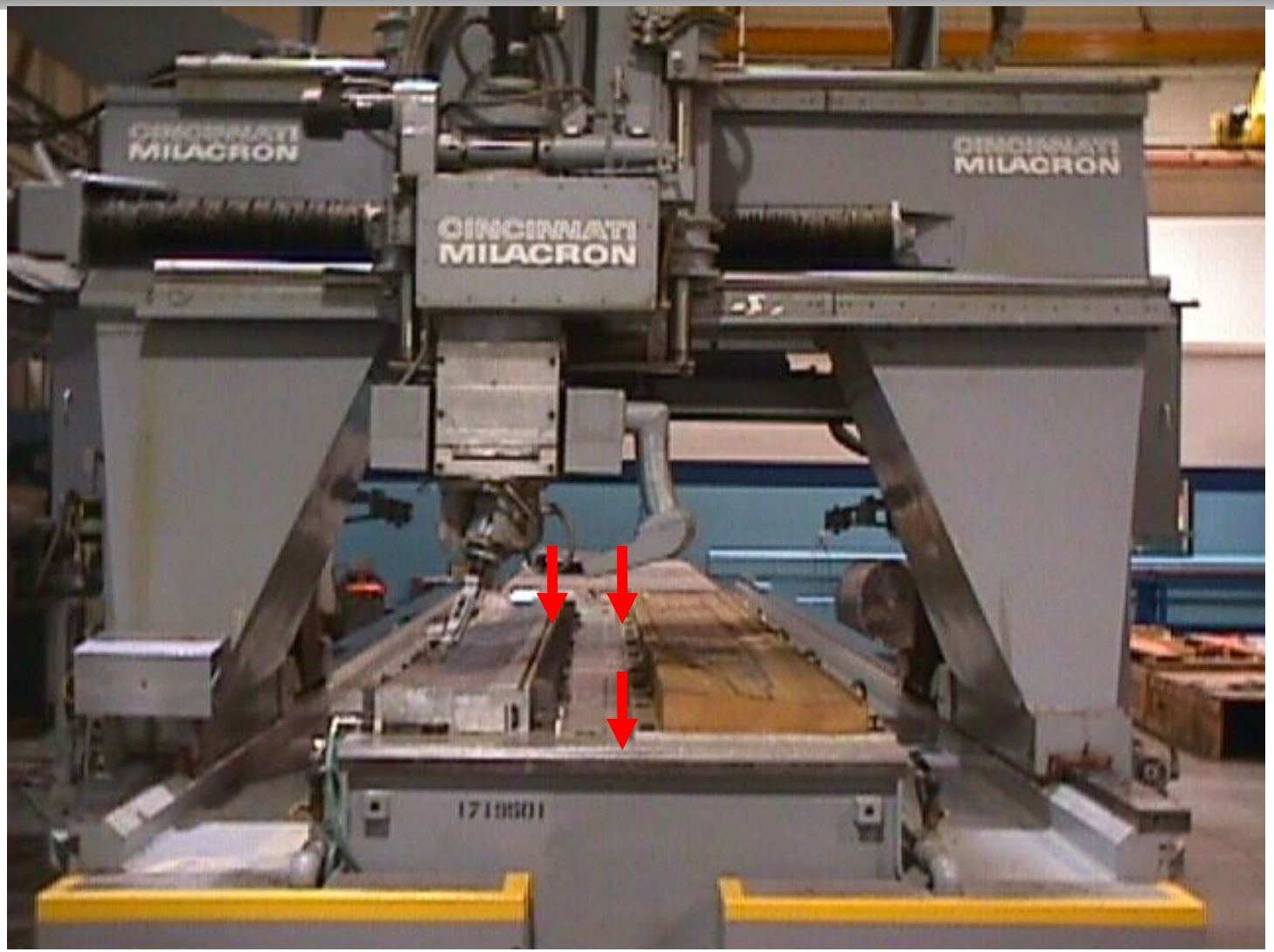
Load Line


ΔX
H
H
AVERAGE
LOAD LINE
LOAD
L
L
UNLOADING-RELOADING
CYCLES
ΔX₀
MOUTH OPENING DISPLACEMENT

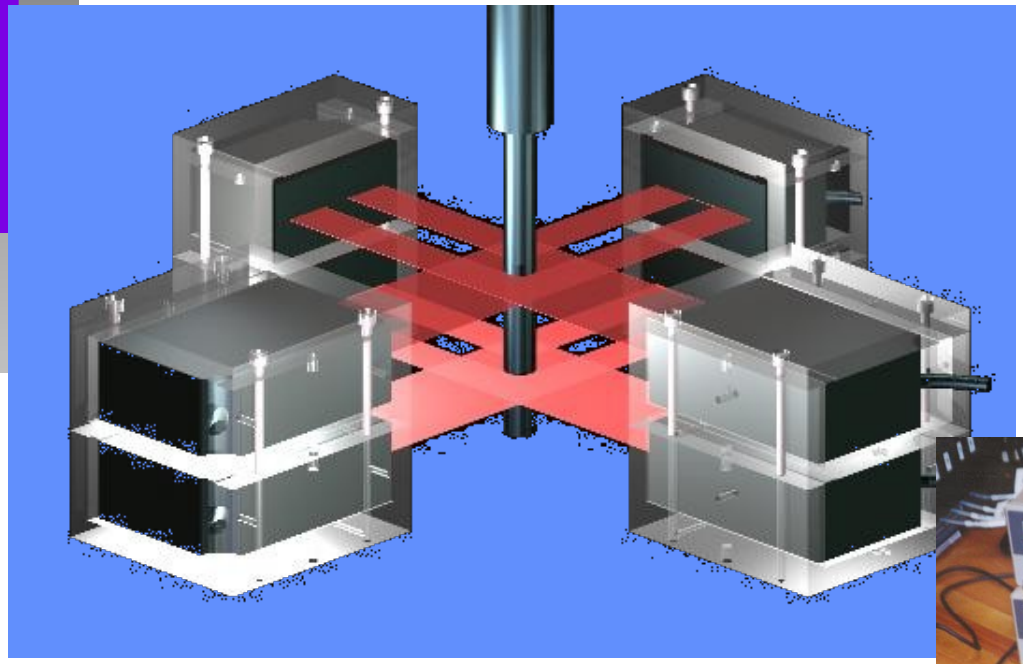
Projects to Date

- ***1999:*** *Laser Assisted Tool Calibration Universal Fixture*
  - *Customer: Bell Helicopter Textron*
  - *Funding: $28,816*

Three Locations

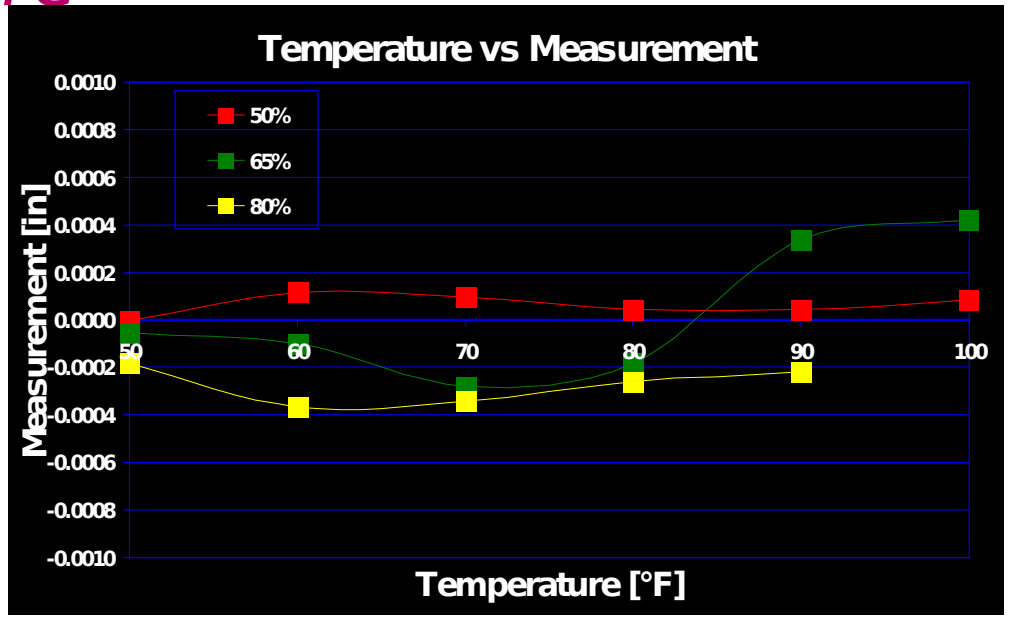


Measurement Theory

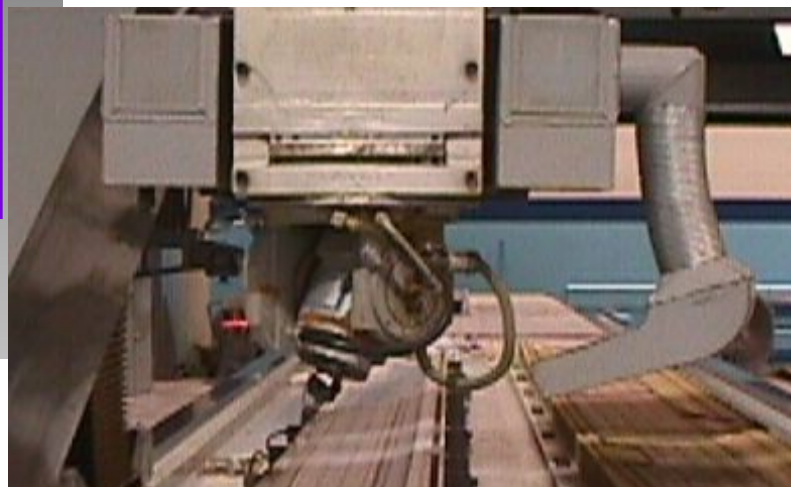


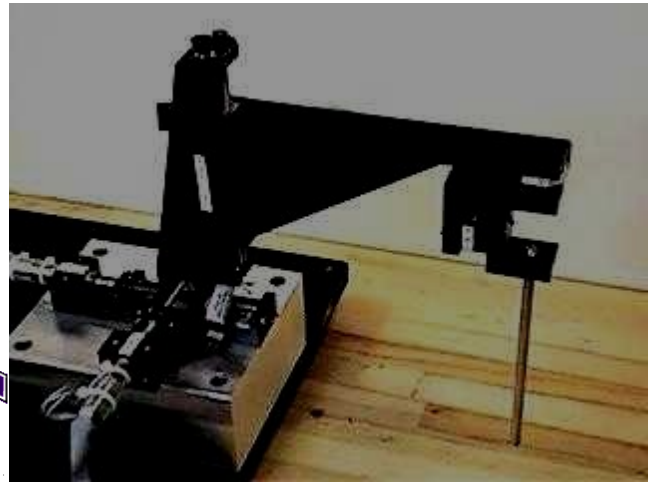
Mechanical Testing

- *Environmental*
  - *Specifications*
  - *Temperature*
  - *Humidity*
  - *Accuracy*



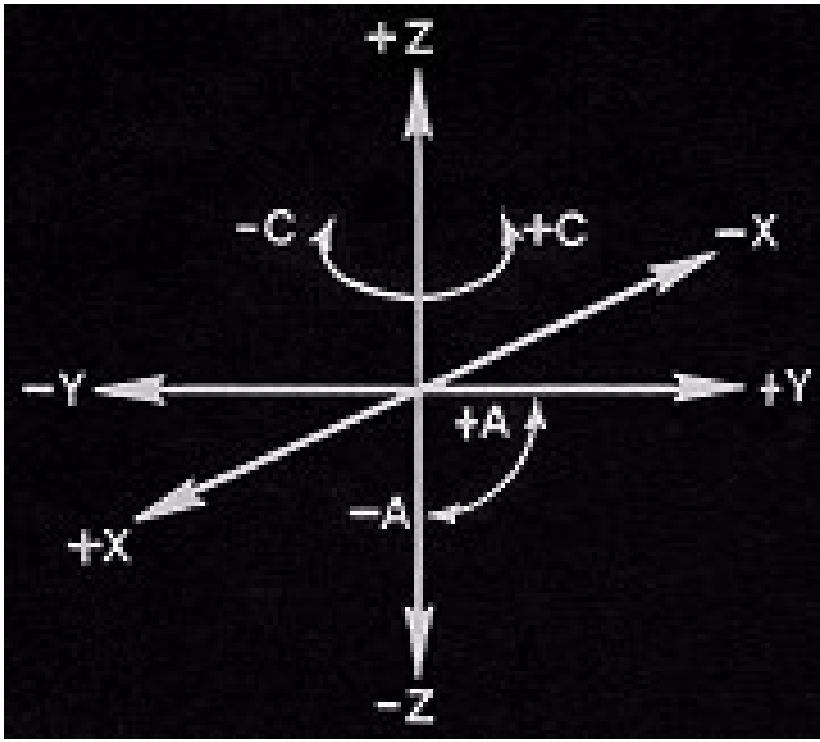
Core Carver





Module Alignment Achievements

- *z-axis*
  - *Goal: 0.007 in.*
  - *Achieved: 0.004 in.*
- *x- and y-axis*
  - *Goal: 0.007 in.*
  - *Achieved: 0.003 in.*
- *a-axis*
  - *Goal: 0.2°*
  - *Achieved: 0.05°*



Projects to Date

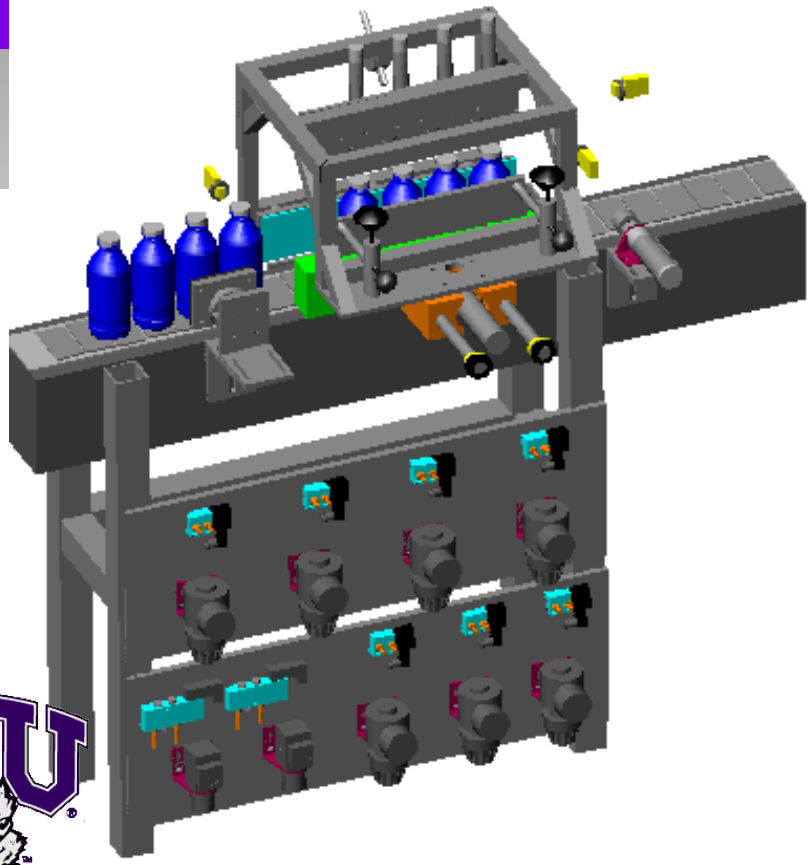
- ***2000:*** *In-Line Vacuum Detection System (winner of Design News 2nd Annual College Design Engineering Award sponsored by ANSYS)*
  - *Customer: Alcon Laboratories, Inc.*
  - *Funding: $27,000*

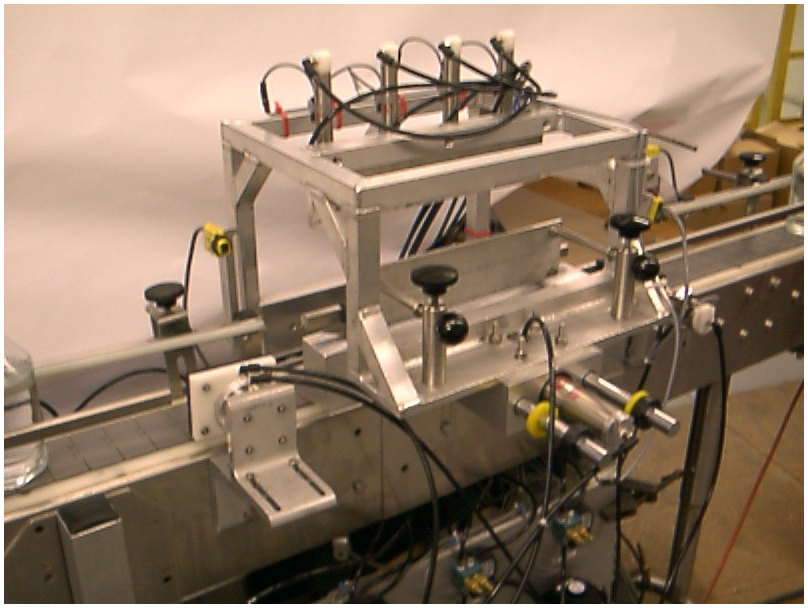
Alcon Request

The students were requested to design an automated process, on a rapidly moving conveyor line, to assess the vacuum levels in Alcon bottles containing a sterile solution used in eye surgery.

- *replace manual syste*
- *65 BPM*
- *250 and 500 ML bott*
- *false accepts 0%*
- *false fails < 0.1%*
- *25 pp specification*

Pneumatic Hammer Assembly





Some Transducers

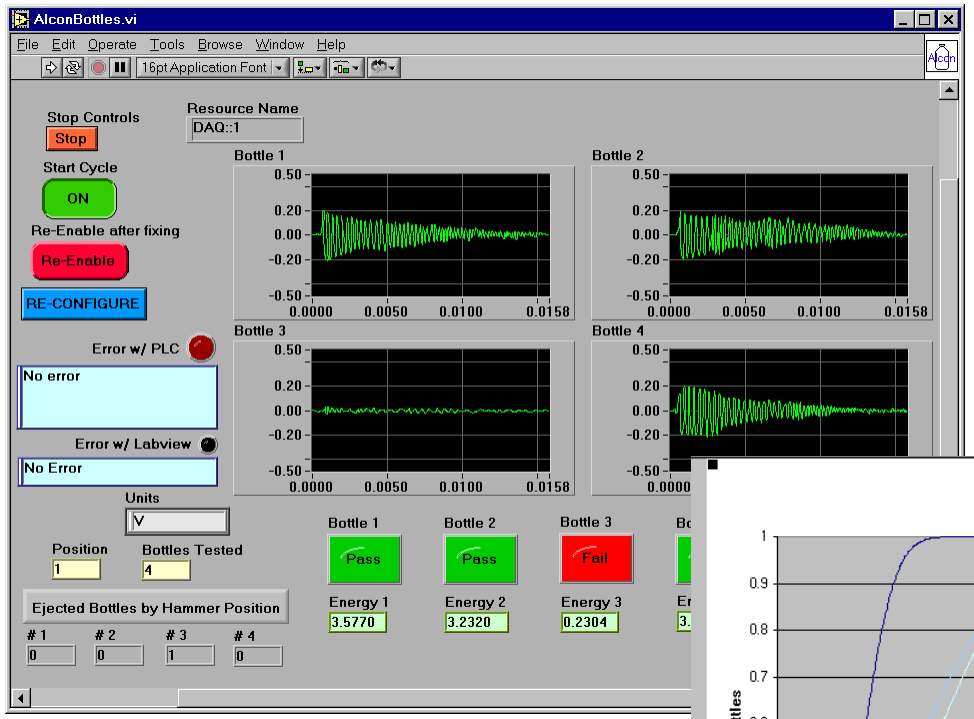
Photoeye

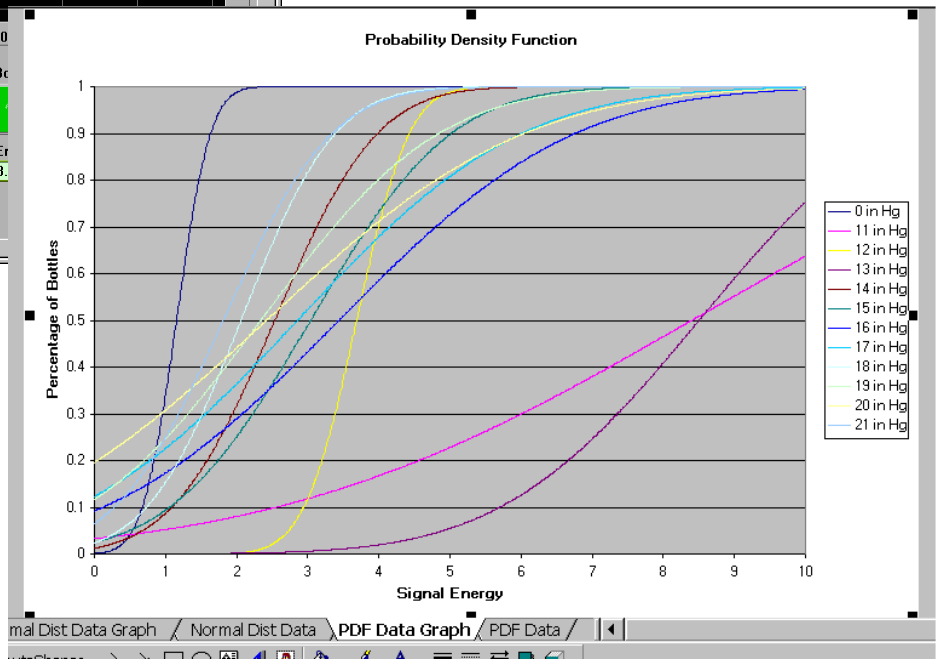
Piston Phone

B&K Microphone

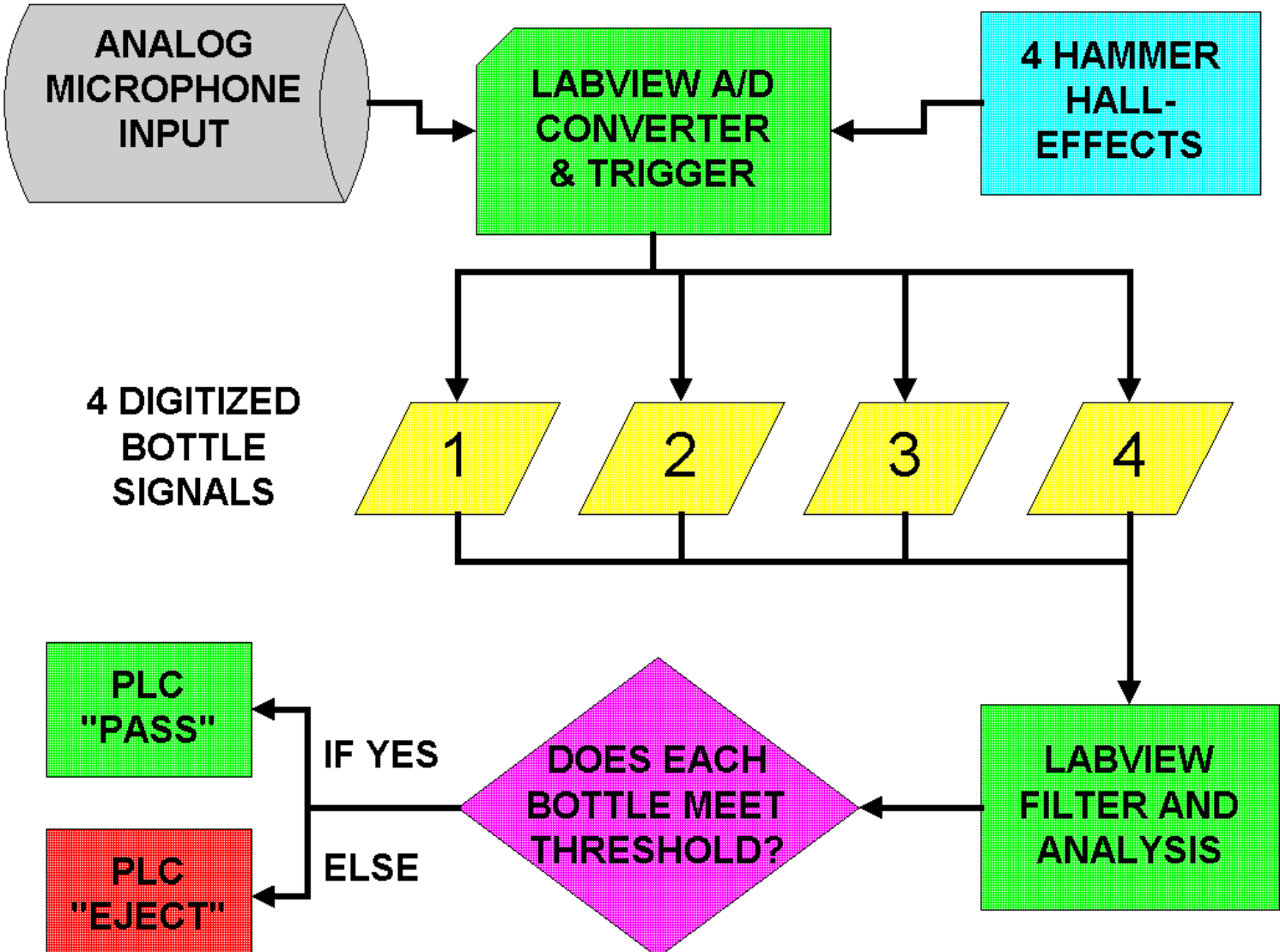
Hall Effect Sensor

Microphone Response

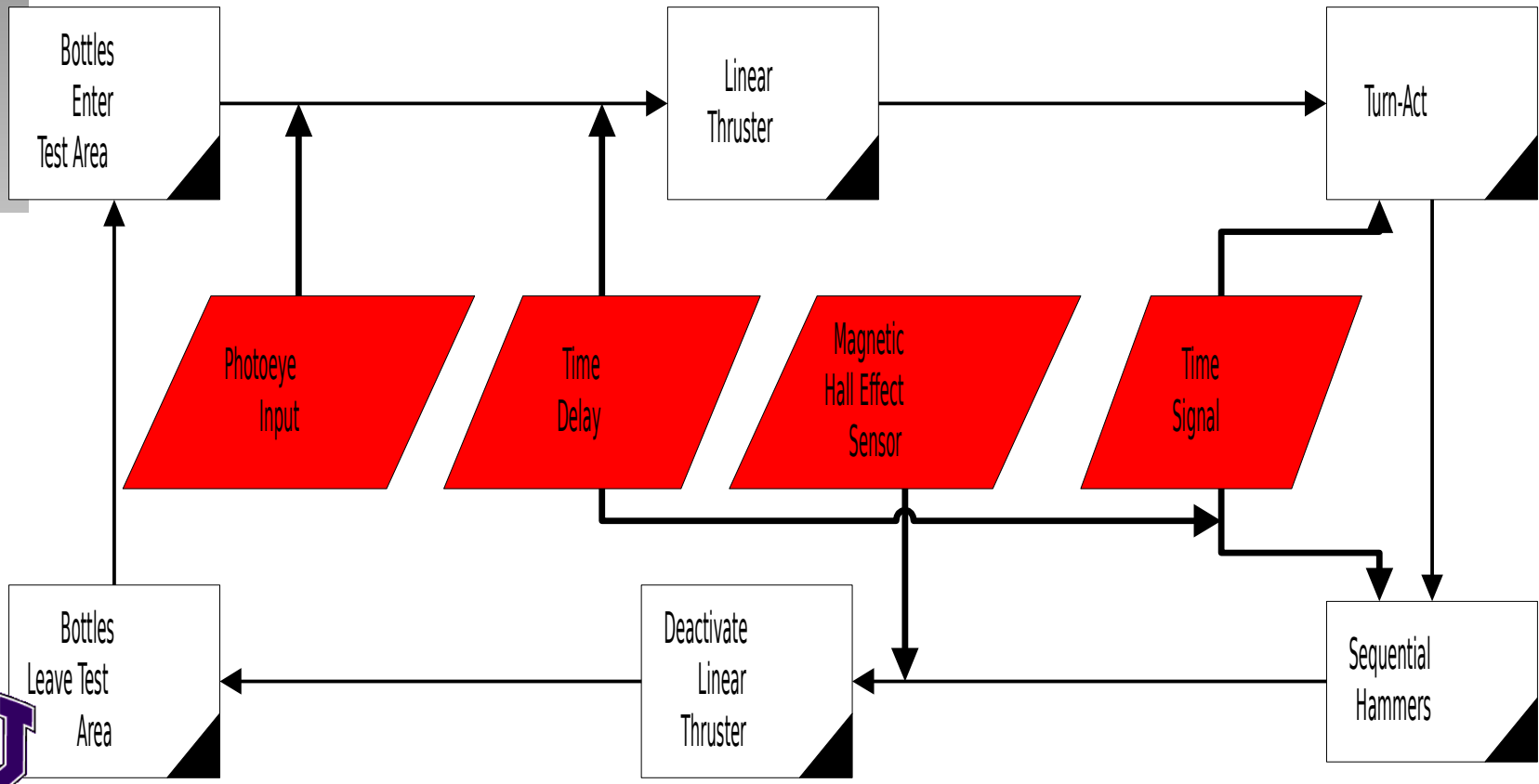




CPU –Analyzing Process



PLC Controls Timer/Delays/Inputs



College Design Engineering Award Sponsored by ANSYS

Projects to Date

- ***2001:*** *Measurement Enhancement of Blast Data*
  - *Customer: U.S. Army Engineer and Development Center - Waterways Experiment Station*
  - *Funding: $15,000*

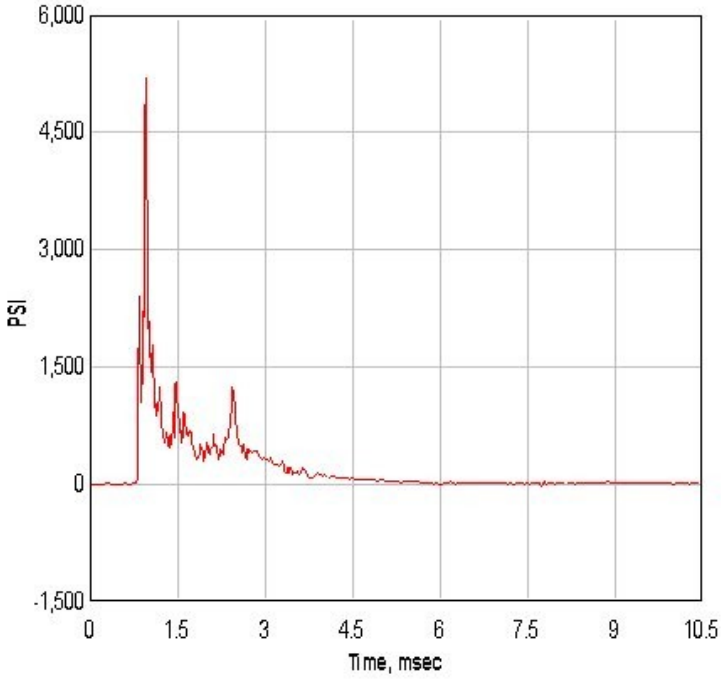
System Diagram

Blast

Blast Wall
1/8” Cable

J-Box

System Diagram



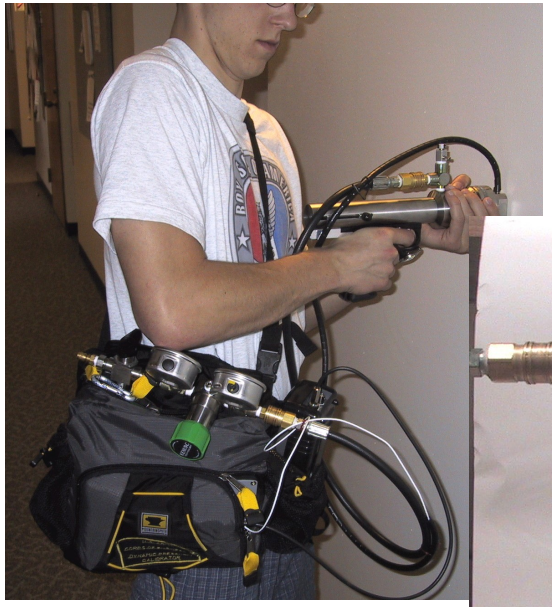
Cable

Amplifier

A/D Conversion

Compute r

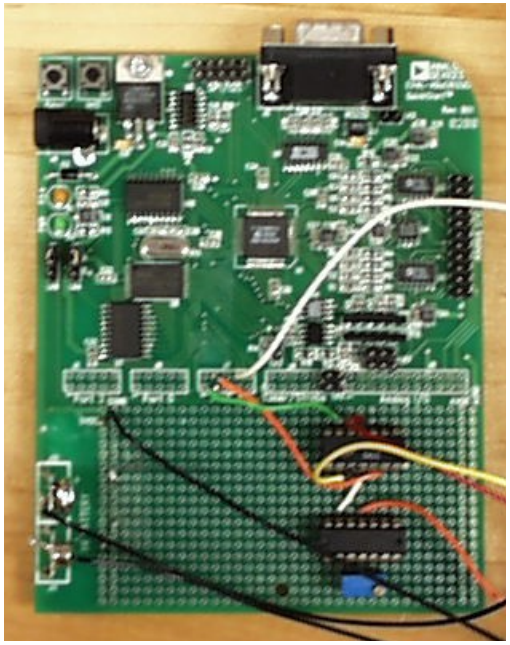
Pneumatic Calibration Gun



Electronics

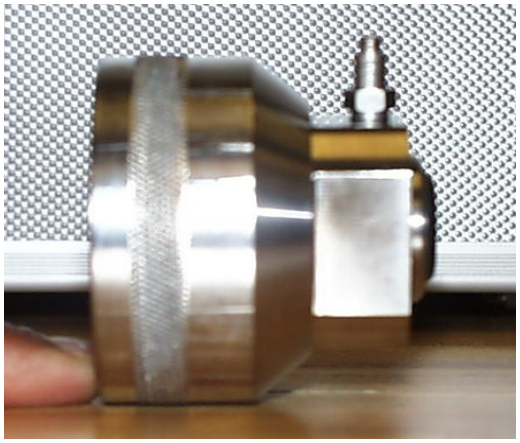
Signal Conditioner

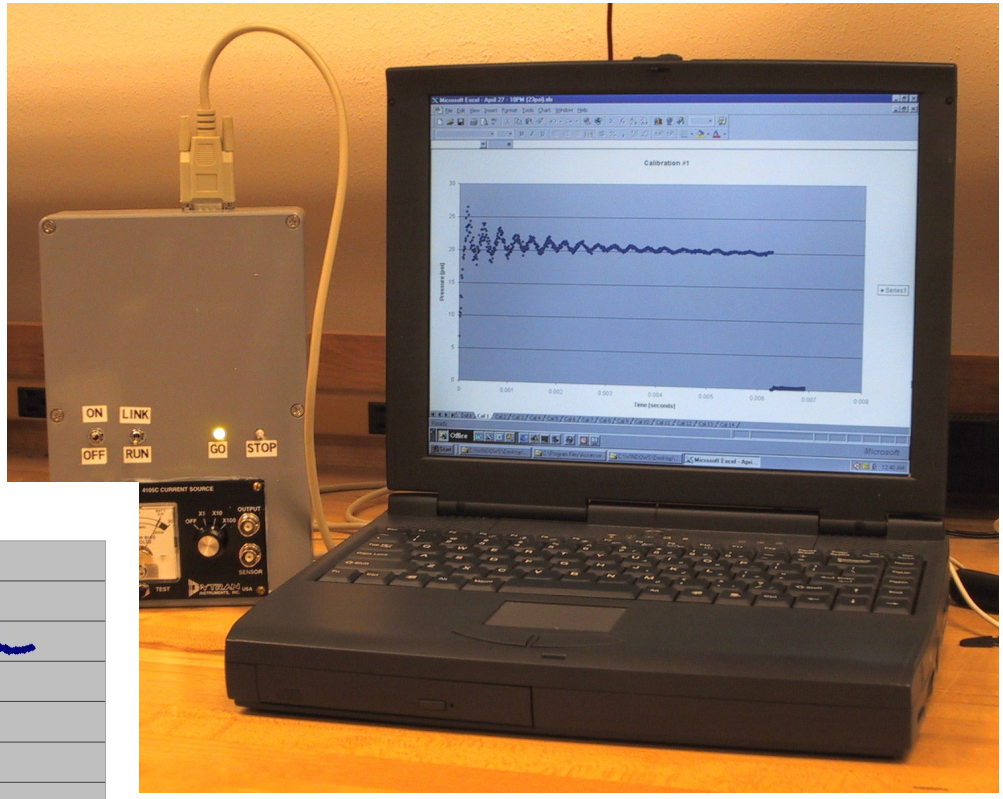
Multisco pe

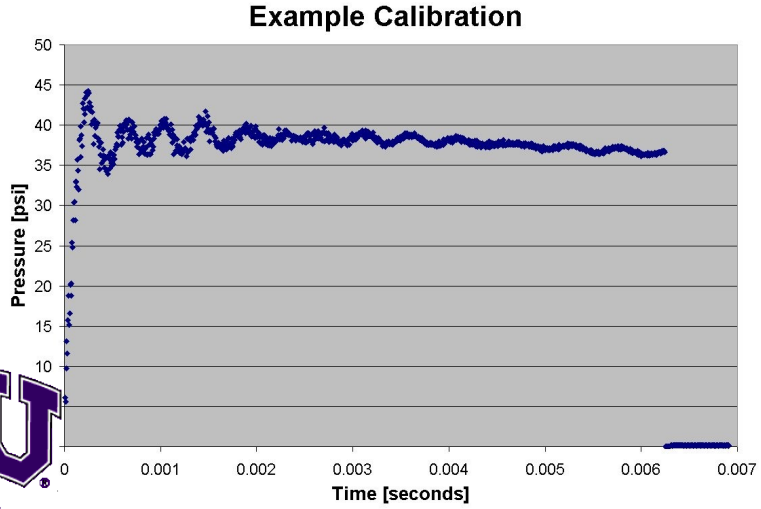


Microproces sor

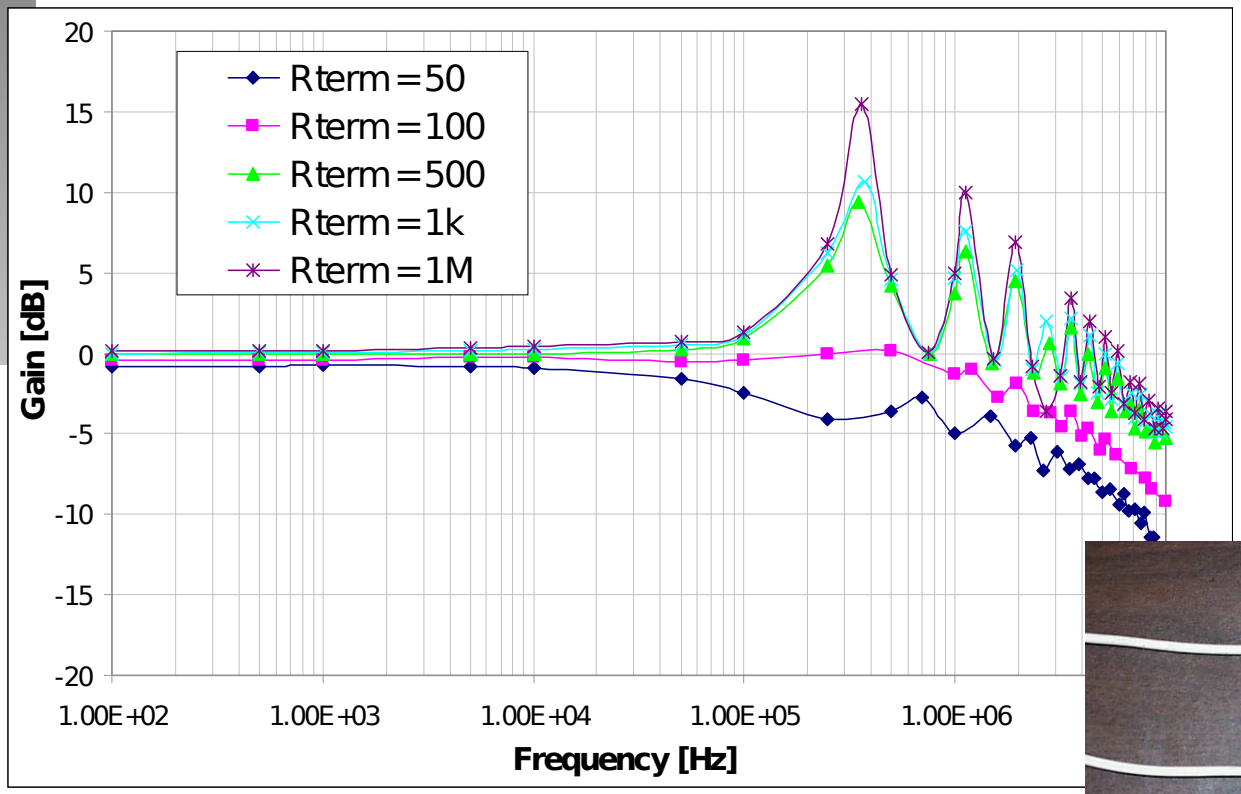
Calibrator Readout

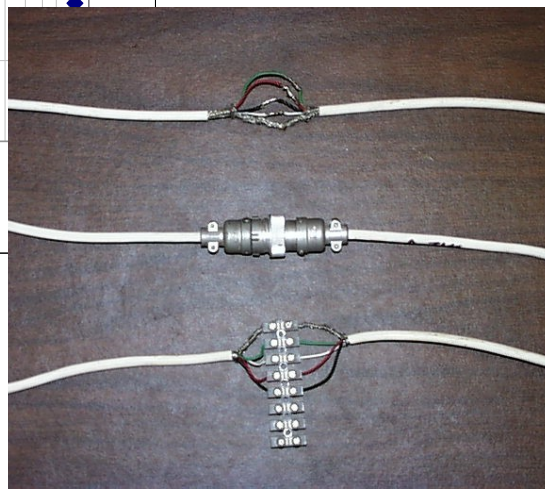




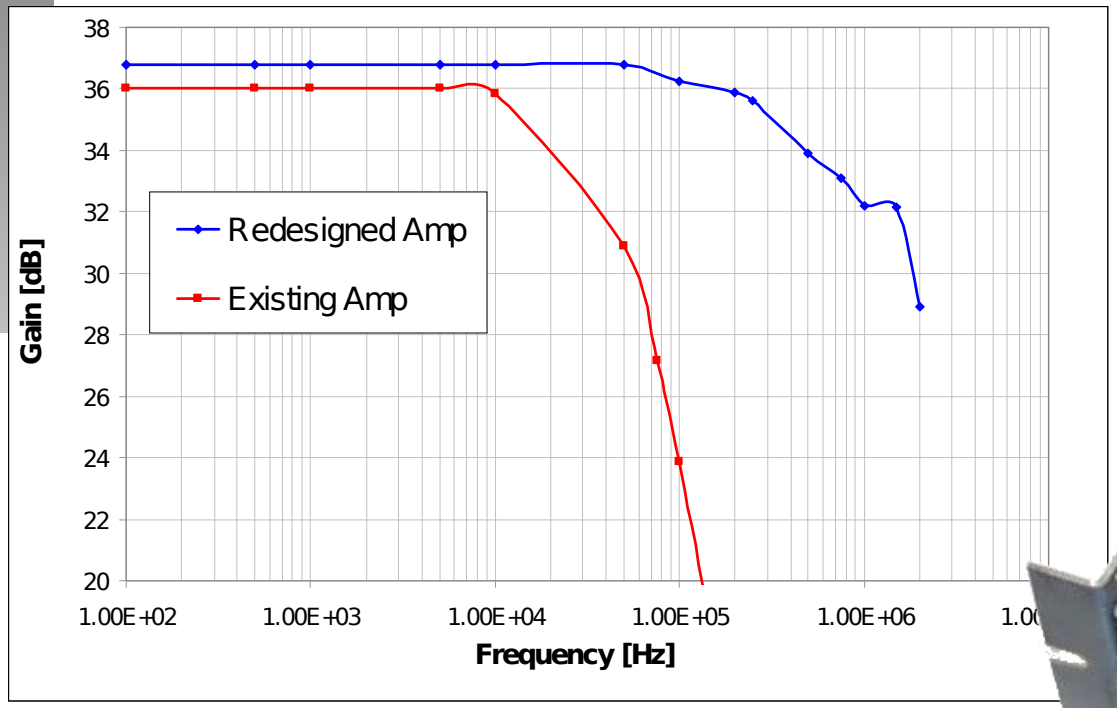


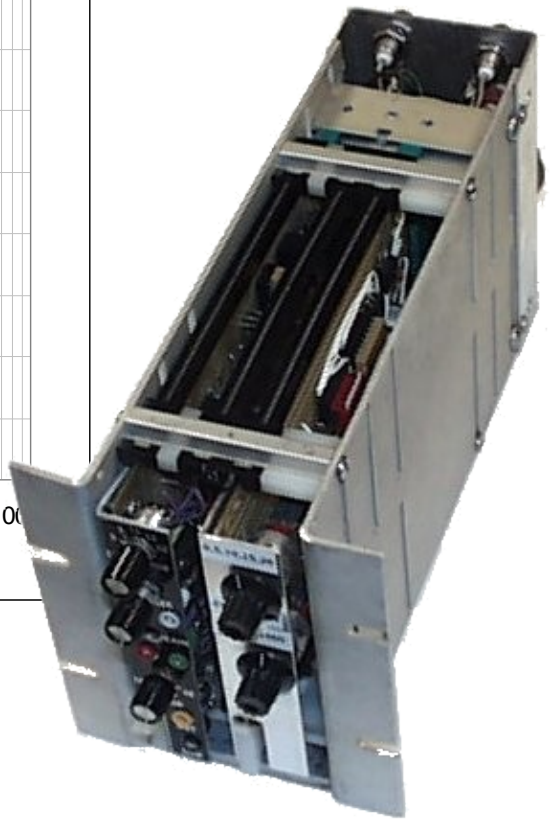
Reflections in Cables



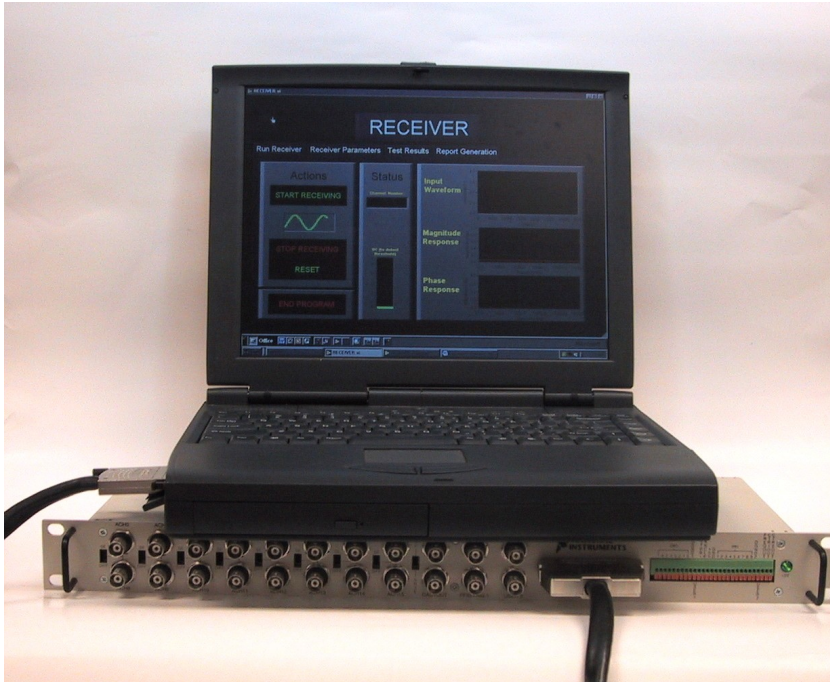


Redesigned Amplifier





End to End System Test



GENERATOR

RECEIVER

End to End System Test

receiver.vi

Monday, April 29, 2002
1:51 AM

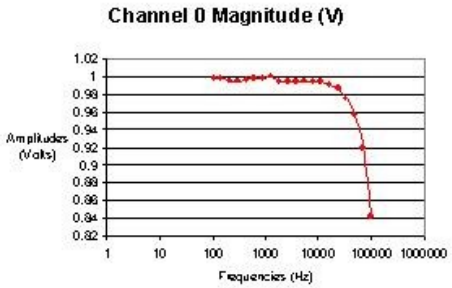
CABLE TEST RESULTS

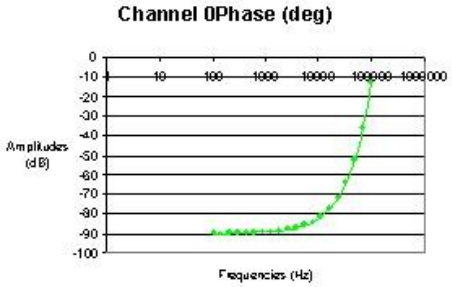
Stop. Collaborate and listen. Ice is back with a brand new edition. Something grabs ahold of me tightly. Flowin like a harpoon daily and nightly. Will it ever stop? Yo! I don't know. Turn out the lights, and I'll glow.

DATA:

Channel 0

Frequencies (Hz)	Magnitudes (Volts)	Magnitudes (dB)	Phases (deg)
104.40	1.00	-0.01	-89.86
144.56	1.00	-0.02	-89.95
208.81	0.99	-0.05	-89.57
297.15	0.99	-0.05	-89.83
433.67	1.00	-0.03	-89.90
618.40	1.00	-0.02	-89.57
891.44	1.00	-0.01	-89.31
1276.93	1.00	0.00	-89.10
1839.10	0.99	-0.05	-88.77
2650.22	0.99	-0.06	-87.81
3806.69	0.99	-0.05	-86.97
5477.13	0.99	-0.05	-85.72
7878.39	0.99	-0.05	-84.10
11331.71	0.99	-0.05	-81.34
16302.91	0.99	-0.08	-77.34
23460.48	0.99	-0.11	-71.87
33730.15	0.97	-0.22	-63.84
48515.20	0.96	-0.39	-52.14
69789.28	0.92	-0.74	-35.79
100387.34	0.84	-1.51	-12.11





and Next Year?

- ***2002:*** *Design and Evaluation of a Hand-Held Measurement Device for Rivet Hole Characteristics*

  - *Customer: Lockheed-Martin Company (Joint Strike Fighter)*
  - *Funding: In progress*

The end- thanks for your interest